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Self-enforcing environmental agreements and trade in fossil energy deposits ☆

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ABSTRACT

The literature on self-enforcing environmental agreements (SIEAs) focuses on de- mand-side emission-reduction policies. To our knowledge, Harstad (2012) is the only study on SIEAs, in which countries purchase fossil-energy deposits to prevent their exploitation. He finds that for any coalition size there exists a (small) subset of parameters, different for each size, such that the coalition of that size is stable. However, the comparison of Harstad's results with the prevailing demand-side SIEA analyses is hampered by major differences in the structure of the respective game models. This paper develops a game model with a deposit market and deposit purchases for preservation that is in line with some demand-side SIEA literature. It turns out that either no coalition is stable or the grand coalition is the only stable coalition. We compare the outcome of our model not only with Harstad's model but also with Eichner and Pethig's (2015) model of the formation of SIEAs in which climate policy takes the form of (demand-side) emissions taxes.

1. The problem

Scientific evidence suggests that stabilizing the world climate at safe levels requires a massive reduction of greenhouse gas emissions, notably carbon emissions from burning fossil fuels. That calls for an effective and encompassing self-enforcing international environmental agreement (SIEA). The first legally binding international agreement on climate change, the Kyoto Protocol, achieved little more than business as usual, and it is unclear whether the ongoing negotiations towards a broad and deep follow-up agreement will be successful. Therefore, improving our understanding of the conditions for effective SIEAs is important. One of the key issues not yet well understood is how the choice of climate policy instruments influences the formation of SIEAs.

There is a growing literature on SIEAs. The early workhorse model of Barrett (1994), Hoel (1992), Carraro and Siniscalco (1993) was further analyzed by Diamantoudi and Sartzetakis (2006) and Rubio and Ulph (2006) and has then been extended into various directions. For example, Hoel and Schneider (1997) introduce transfer schemes in the coalition formation process, Finus and Pintassilgo (2013) study uncertainty and learning. This literature models climate policy as emissions-cap policy, disregards international trade and is quite pessimistic about large and deep stable climate coalitions. Eichner and Pethig (2013, 2015) focus on the role of international trade and show that the grand coalition may be stable when countries

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use emissions taxes rather than emissions caps. The common feature of that literature - and of the climate policy in practice - is that policy takes the form of emissions caps, emissions taxes, or cap-and-trade systems. In contrast to these extensively studied demand-side climate policies, supply-side policies are under-researched. Our paper seeks to improve the understanding of SIEAs with supply-side climate policies. Specifically, we will envisage a world economy with an international market for (the right to extract) fossil energy deposits,[1] in which governments curb carbon emissions by purchasing *and preserving* some of those fossil fuel deposits, which the sellers would have exploited otherwise.

To our knowledge, Bohm (1993) and Harstad (2012) are the only studies with an analytical approach to the climate policy of buying deposits for preservation.[2] Bohm (1993) shows that a special policy mix with the purchase or lease of deposits may implement an emissions cap at lower costs than the stand-alone fuel-demand-cap policy. Harstad (2012) also considers a policy mix with deposit purchases and shows in his basic model with a climate coalition of given size that the coalition implements the first-best despite acting strategically on the fuel market.

The first and only analysis of the formation of SIEAs with supply-side climate policy we are aware of is due to Harstad (2010, 2012).[3] He finds that coalitions of any size - including the grand coalition - may be stable, if governments are buying and firms are selling deposits.[4]

It would be both important and interesting to compare Harstad's supply-side SIEA analysis with extant studies of SIEAs with demand-side climate policies. Unfortunately, the comparability is hampered by major differences in the structure of the respective game models. Harstad's climate coalitions implement a policy mix of (take-it-or-leave-it) deposit purchases and set caps on own fuel demand and supply strategically in a four-stage game in which the deposit market clears prior to the fuel market. In contrast, those contributions to the SIEA literature with demand-side policies, which model international trade and hence are candidates for comparison, assume markets with uniform prices that clear simultaneously and they assume climate damage that is progressive (quadratic) in aggregate emissions while Harstad's damage function is linear.[5]

The aim of the present paper is to develop a game model with deposit purchases for preservation that is more in line with extant models on SIEAs with demand-side policies and thus allows for a meaningful comparison with these models. Our model is characterized by international markets with uniform prices that clear simultaneously, by deposit purchases being the only policy parameters, by the coalition and all fringe countries playing Nash, and by climate damage being progressive or linear in aggregate emissions. In contrast to Harstad (2012, 2010), we find that either no coalition is stable or the grand coalition is the only stable coalition.

The basic structure of the model we will develop in the present paper is the same as the structure of the model on the formation of SIEAs with emissions taxes in Eichner and Pethig (2015). That enables us to compare the influence of emissions taxes and deposit purchases on the formation of SIEAs in a meaningful way. The interesting result of that comparison is that there exist proper subsets of parameters in both models, for which the grand coalition is stable, but that those subsets differ across models in a way detailed in the text. The consequence of having developed our supply-side model for the purpose of securing comparability with the relevant demand-side literature is that our approach differs substantially from Harstad's supply-side model. That makes it necessary and interesting, in turn, to compare the outcome of both supply-side approaches to the formation of SIEAs.

After having set up the analytical framework in Section 2, we study the game between a coalition of given size and the non-cooperative fringe countries in Section 3.1. The coalition plays Nash against the fringe countries and each fringe country plays Nash against the coalition and all fellow fringe countries. We characterize the equilibrium allocations for alternative coalition sizes (Proposition 1). The information how the countries' equilibrium payoffs (welfares) depend on the coalition size is necessary for examining the coalition stability in Section 3.2. In a parametric version of the game model we derive in Section 3.2 necessary and sufficient conditions for the stability of the grand coalition (Proposition 2) and show that either no stable coalitions exists or the grand coalition is the only stable coalition (Proposition 3). Section 4 briefly compares the results of our supply-side model with the results of Harstad's supply-side model (Proposition 4) and with the results of the 'demand-side model' of Eichner and Pethig (2015) in which the climate policy takes the form of emissions taxation (Proposition 5). To make these comparisons conclusive, we had to develop two different versions of the parametric game model in Section 3, one with linear and the other one with quadratic climate damage.[6]

[1] Harstad (2012) points out that a market for fossil-energy deposits and other minerals already exists between countries and international companies as well as between countries.

[2] Asheim (2013) also deserves mentioning who investigates the use of deposit policies as a distributional instrument in a growth model á la Dasgupta-Heal-Solow-Stiglitz.

[3] In Harstad (2012, p. 105), the participation analysis is very short. Harstad (2010) is a discussion paper version of Harstad (2012) that is a bit more detailed than Harstad (2012) on that issue. See Harstad (2010, p. 29 n. and p. 42).

[4] Harstad (2012) also analyzes the case that the governments (instead of extraction firms) supply deposits for preservation and finds that then no stable coalitions with more than two members exist. Our paper focuses on the sale of deposits by extraction firms exclusively. The crucial driver of Harstad's results is his concept of deposit market equilibrium defined as a set of bilateral deposit trades without uniform price that exhaust all mutual advantages. We underscore the dependence of Harstad's results on the design of his deposit market by demonstrating in the Appendix C that no stable coalition exists, (i) if we replace his deposit market with a perfectly competitive market and (ii) if all countries and the coalition are price takers on the fuel market. The condition (ii) is satisfied in Harstad's model, because the coalition's attempt to manipulate the fuel price in its favor fails to be effective.

[5] See e.g. Barrett (1994), Diamantoudi and Sartzetakis (2006), Rubio and Ulph (2006) and Eichner and Pethig (2013, 2015). The relevant shape of the damage function is a (difficult) empirical question, of course.

[6] Technically speaking, progressive damage aggravates the countries' non-market interdependencies. A co-benefit of deriving the results for linear and quadratic damage is to clarify the impact of progressive damage on the formation of stable coalitions.